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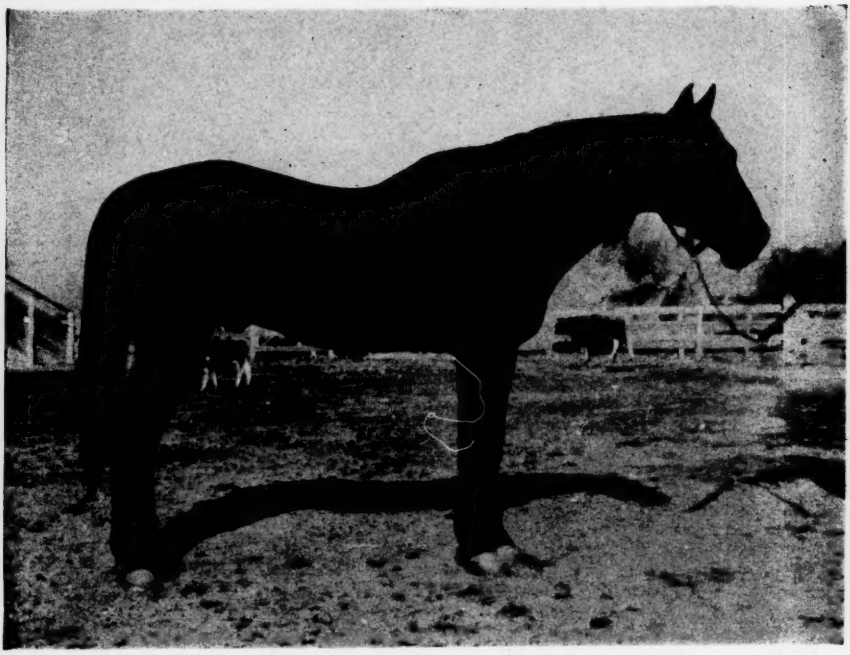

OLD SORREL, 1915-1945

(SEE PAGE 228)

Fur on the Cob

Filial Chromosomes

Natural Color Variety in Flies

VOLUME 37 AUGUST, 1946 NUMBER 8

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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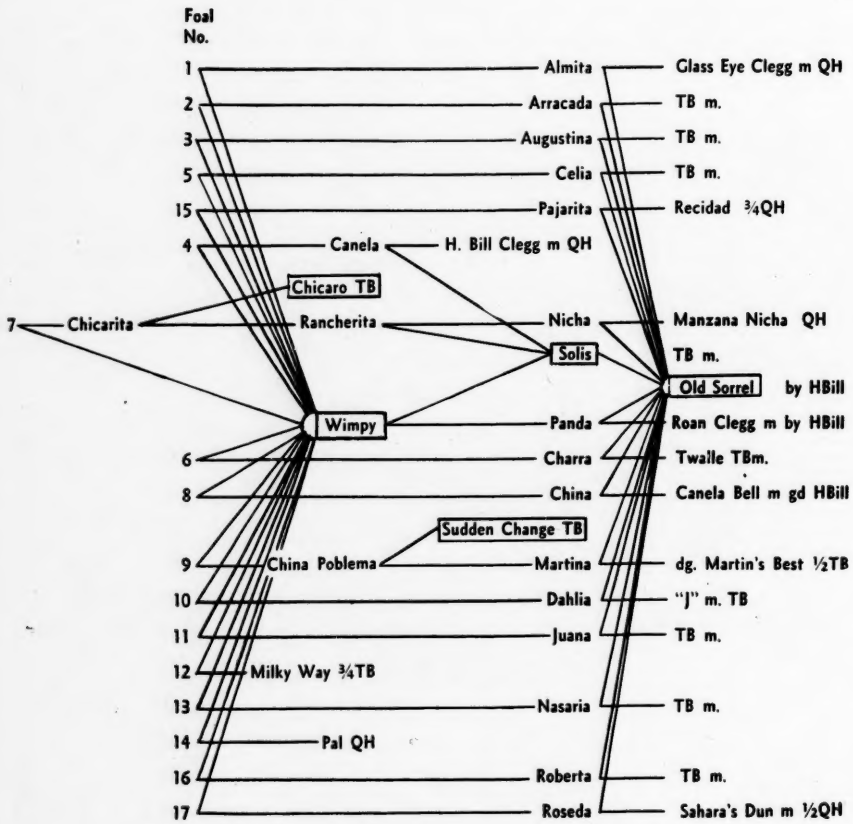

MATINGS TO WIMPY

Figure 1

Wimpy, a double grandson of Old Sorrel, was mated to mares whose average relationship to him was equivalent to their being his half-sisters. Wimpy's foals derived nearly half (44.9 per cent) of their genes from Old Sorrel; 67 per cent of their genes were derived from the Quarter Horse breed, the remaining 33 per cent from the Thoroughbred. In the four network pedigrees (Figures 1, 4, 6 and 8), all sires are symbolized by being boxed in; all horizontal lines trace female lines of descent, all diagonal lines trace male descent. The foals are numbered consecutively in an alphabetical listing of their dams. Example: foal number one is out of Almita by Wimpy. Almita is out of the Glass Eye Clegg mare by Old Sorrel.

THE DEVELOPMENT OF A SUPERIOR FAMILY IN THE MODERN QUARTER HORSE

A. O. Rhoad and R. J. Kleberg, Jr.*

INFORMATION on the formative period of established livestock breeds is of special interest to animal breeders and to those who are endeavoring to interpret breeding programs in terms of gene frequencies and population genetics. Analyses based on such data are also a valuable guide in the development of new breeds.[3] There is at this time a renewed interest in the production of specialized breeds to fit specific uses or conditions. With the increased insight afforded by genetic principles, breeders and animal husbandmen are able to fashion new breeds with increasing efficiency. The modern Quarter Horse is an example.

The Quarter Horse breed is at once old and new. From the early colonial period through the first quarter of the Nineteenth Century, the Quarter Horse played a prominent part in furnishing riding stock to the colonists. The breed got its name from the quarter-mile races which were extremely popular during the colonial period. When the Thoroughbred became well established in the first half of the Eighteenth Century in America, interest in quarter-mile races declined, and the Quarter Horse as a breed almost disappeared. During the westward migrations of the early Nineteenth Century the Quarter Horse went West with the pioneers and became disseminated throughout the cattle ranches then being established in the range country. There it found a second opportunity for service. Crossed with the equally hardy but less fleet Spanish *Criollo* horse of the plains, the Quarter Horse achieved its greatest usefulness as the cow-horse of the ranchers.

Because of the very important place the horse had in ranch operations, the improvement of ranch horses through selective breeding was given earnest consideration by progressive ranchers. In a few instances, attempts were made to retain the old and almost lost lines of eastern Quarter Horse breeding. Others sought to add quality to the numerous horses of mixed heritage by crossing with the most compact type of Thoroughbred. From this beginning the modern Quarter Horse has developed in the past hundred years.

Until very recently the breed had no clearly defined standards, nor did it have a formal existence. In 1940 a group of ranchers interested in re-establishing the Quarter Horse as a distinct breed organized The American Quarter Horse Association. The new, or modern Quarter Horse is, therefore, still in its formative period, and at this time the registry of the breed is not closed. This Association has recently published the first two volumes of its Stud Book and Registry.[1]

Quarter Horse Breeding at King Ranch

During the entire history of the King Ranch it has always raised a great many horses and used them in its operations. Its efforts have constantly been to improve its horse stock. Many times in its history it has had stallions that individually produced very useful cow horses. It has been our sad experience that the good qualities passed on by these stallions often disappeared in the second generation, so that we were alive to the need for a breeding program planned toward a more consistently fixed type for

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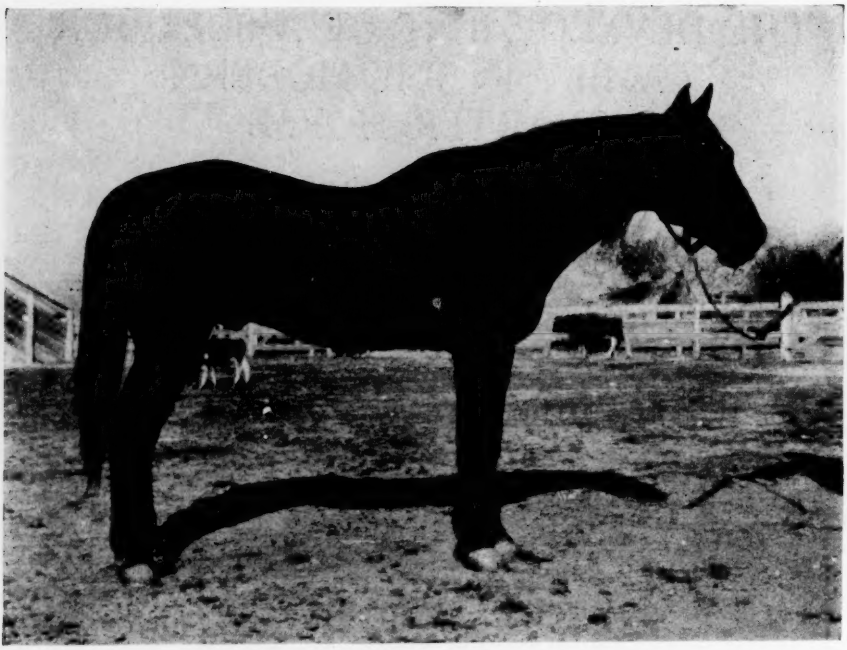


OLD SORREL

Figure 2

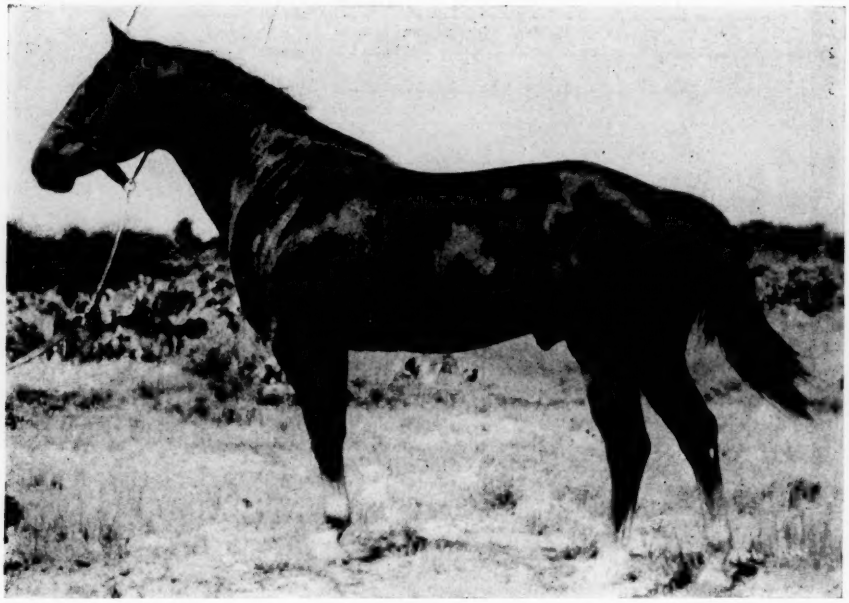
The foundation sire of the King Ranch strain of Quarter Horses was the finest cow horse ever seen on the King Ranch. Old Sorrel lived from 1915 to 1945. Six of his sons and several score of his daughters have been the foundation stock for a linebreeding program now in its fourth and fifth generation. Among the younger highly inbred descendants of Old Sorrel are to be found the finest cow horses ever produced by the King Ranch.

the economical production of ranch horses.

Of the various lines of breeding represented in these volumes, one of the most prominent in numbers and reputation is that embracing the descendents of Old Sorrel 209, founder of the King Ranch strain. Old Sorrel 209 was foaled in 1915 and died in 1945 at the ripe age of 30 years. He was a grandson of Peter McCue, and a son of Hickory Bill, identified by Fletcher[2] as the two most prominent sires of the breed as registered in the A. Q. H. A. Studbook. The dam of Old Sorrel was a Dr. Rose mare. She was brought to Texas from Kentucky. Her ancestry is unknown, but from her appearance she carried considerable Thoroughbred blood.

Old Sorrel was purchased as a colt from Mr. George Clegg of Alice, Texas, for use on the King Ranch. When he was broken and tried for cattle work, Old Sorrel proved to be outstandingly the best cow horse we had ever had on King Ranch. He was exceptional as to beauty, disposition, conformation, smoothness of action and fine handling qualities. Having seen other stallions, even after they had proven their merits for breeding, carry on for only one generation, we determined, if possible, to perpetuate the wonderful qualities of this stallion.

The first constructive effort in this direction was to breed Old Sorrel to fifty of the best handling and best riding mares on the ranch. These mares



WIMPY

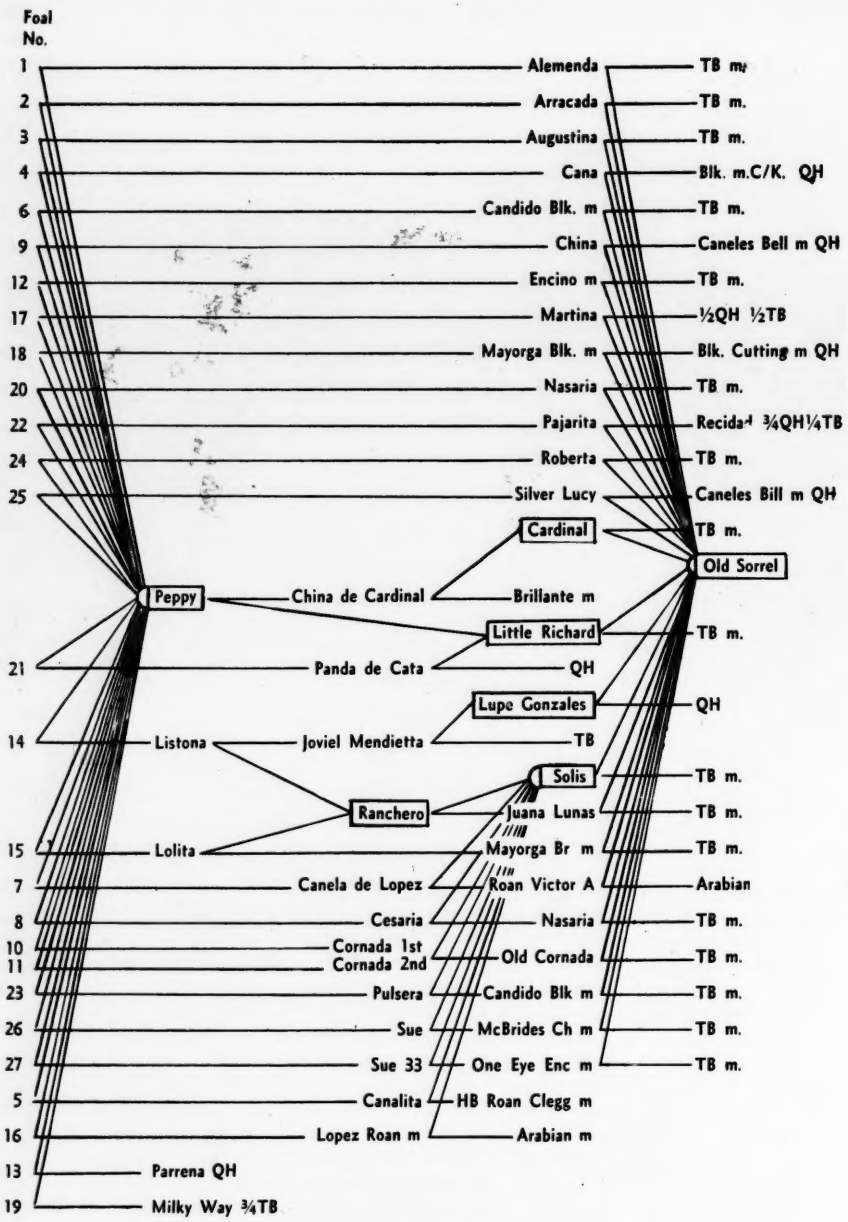
Figure 3

Wimpy is a double grandson of Old Sorrel and a triple great grandson of Hickory Bill. Hence Wimpy is as closely related to Old Sorrel as a son, and three-quarters as closely related to his grandfather, Hickory Bill. Mating him to daughters of Old Sorrel has resulted in the production of the most highly inbred group of colts in the experiment.

were in most instances of pure Thoroughbred or grade Thoroughbred breeding. The first important effort toward concentrating and preserving his blood was made when Solis, one of Old Sorrel's sons out of a Thoroughbred mare, was mated to his daughters from this same band of mares. In the course of a very short time, this band of mares was built up to 35 or 40 in number and in this way Solis was mated to forty of his half-sisters mostly from Thoroughbred mares. The results of this mating were very gratifying and it was clear that a long stride toward a fixed type had been made in this first mating.

During this same period, six other sons of Old Sorrel were bred to selected bands of mares which were thought best suited them, and in this way quite a large population of grandsons and granddaughters of Old Sorrel was produced. In all instances the stallions and mares above referred to were broken to ride and were sufficiently tried out so that our permanent records regarding them were based on an intimate knowledge of their characteristics under the saddle as well as on their appearance. Fairly good results were obtained from those first matings, but the best results were obtained from the close breeding employed in the case of Solis.

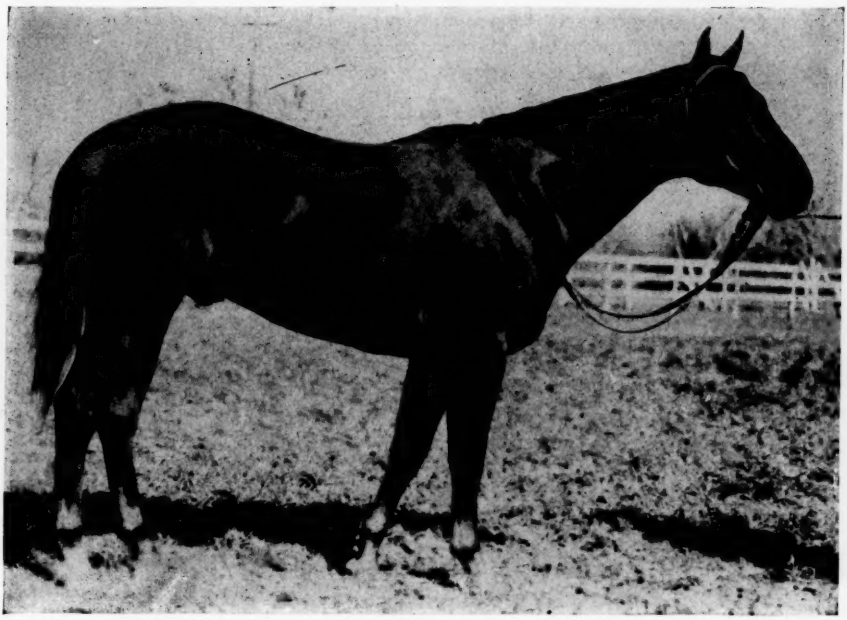
As soon as it was possible to do so, selections were made from the related offspring above mentioned. In all cases the plan was to employ only such matings as would complement each other as to disposition, conformation and the great variety of characteristics which make up any living creature. An example of this type of mating would be the



PEPPY'S PROGENY

Figure 4

Peppy, only 6.5 per cent inbred to Old Sorrel, was most frequently mated to daughters of Old Sorrel, so that his progeny are more closely related to Old Sorrel than Peppy himself is. Peppy's offspring are somewhat less highly inbred than Wimpy's.



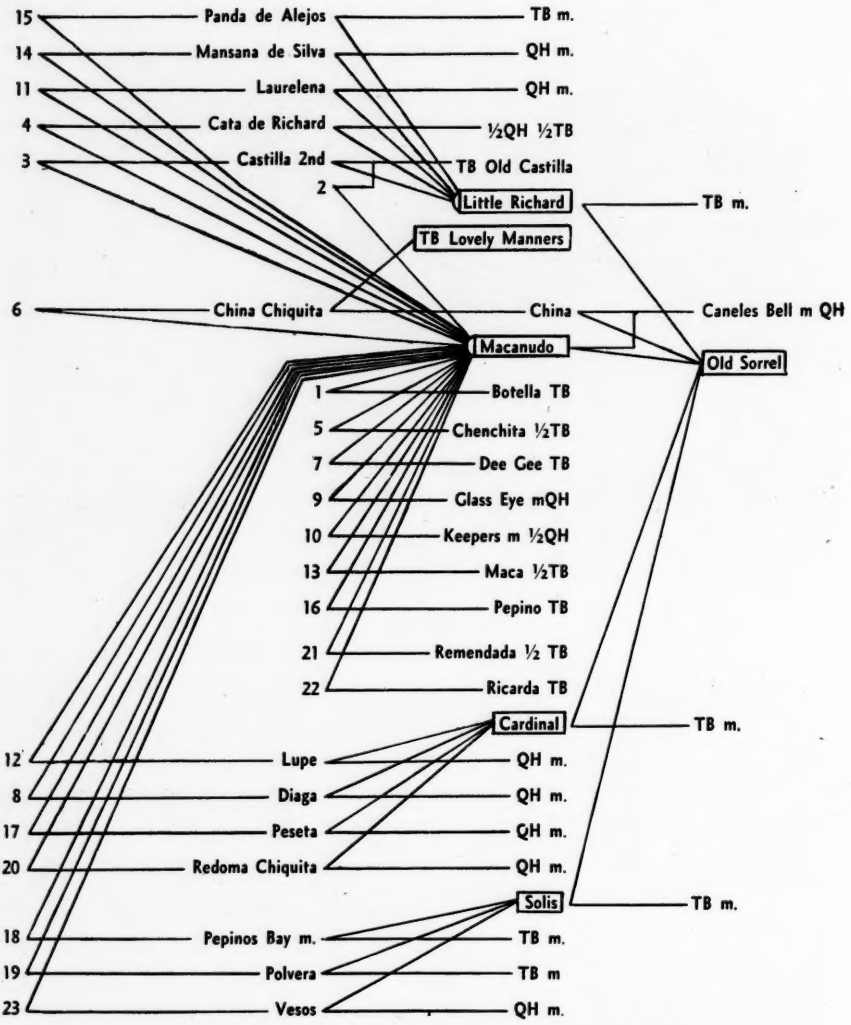
PEPPY

Figure 5

Peppy is a double grandson of Old Sorrel, produced by mating a daughter of Cardinal to her uncle, Little Richard. This combines in one individual the superior qualities of two of Old Sorrel's outstanding sons. Among Peppy's offspring are found some of the finest Quarter Horses ever produced at the King Ranch.

breeding of the stallion Little Richard (who was by Old Sorrel out of a Thoroughbred mare) to the daughters of Cardinal (also by Old Sorrel out of a Thoroughbred mare); both Little Richard and Cardinal were almost of identical conformation and were practically perfect individuals. Little Richard, however, was above average size for the breed; he was inclined to be sluggish and did not have as light a mouth as is desirable. Cardinal, on the other hand, was below average size, was inclined to be a little high-strung and his mouth was almost too light. From this mating, we secured a closer approach to the desirable traits that Old Sorrel possessed. Similar constructive results were obtained in mating Cardinal to the daughters of Little Richard. The two above examples are given simply because they illustrate some of the factors in the whole breeding plan. Through the years, as especially desirable individuals were produced, attention was given constantly to concentrating those traits which would actually improve the breed and this method has been used throughout the plan.

The ideal type and the superb performance of Old Sorrel under the saddle led his owners to use him extensively in their breeding plans. The manner in which he transmitted his good qualities to his descendents, showing his great prepotency, made it seem advisable to perpetuate these qualities through a carefully planned and controlled experiment in line-breeding and inbreeding. They were fully aware that not every exceptional sire has a balance of genetic qualities which will stand the test of



MACANUDO WAS MATED TO OLD SORREL'S GRANDDAUGHTERS

Figure 6

Macanudo was mated to his nieces, and outcrossed to Quarter Horse and Thoroughbred mares. This more than doubled the genes derived from Old Sorrel in the foals as compared with their dams. Some of the finest individuals produced in these experiments have come from matings of uncles and nieces such as those shown here. Cross-matings between the descendants of Little Richard and Cardinal have been particularly successful.

close inbreeding without disaster. The only way in which this could be determined was by actual trial. He was mated on a few occasions to his best daughters and the results, while encouraging, were not exceptional. But when his son Solis was mated on Old Sorrel's daughters the results were so good that the management decided to try to perpetuate Old Sorrel through line-breeding and in-breeding.

Materials and Methods

This study is based on the pedigrees of 77 of Old Sorrel's inbred descendents of the 1941 and 1942 crop of foals scheduled to come up for registration as two-year-olds. Not all of the pedigrees were complete as to names, especially for some of the dams in the earlier generations, nor were the foals named when this study started. It was possible, however, to determine whether the unnamed ancestors in these pedigrees were Quarter Horse or Thoroughbred. The former category includes all named animals of Quarter Horse breeding as well as cowhorses of unknown ancestry. All animals that were straight-bred Thoroughbreds were known, although many did not carry names. In designing the network pedigrees, the material was grouped according to the sires and the band of mares to which each of these sires was mated.

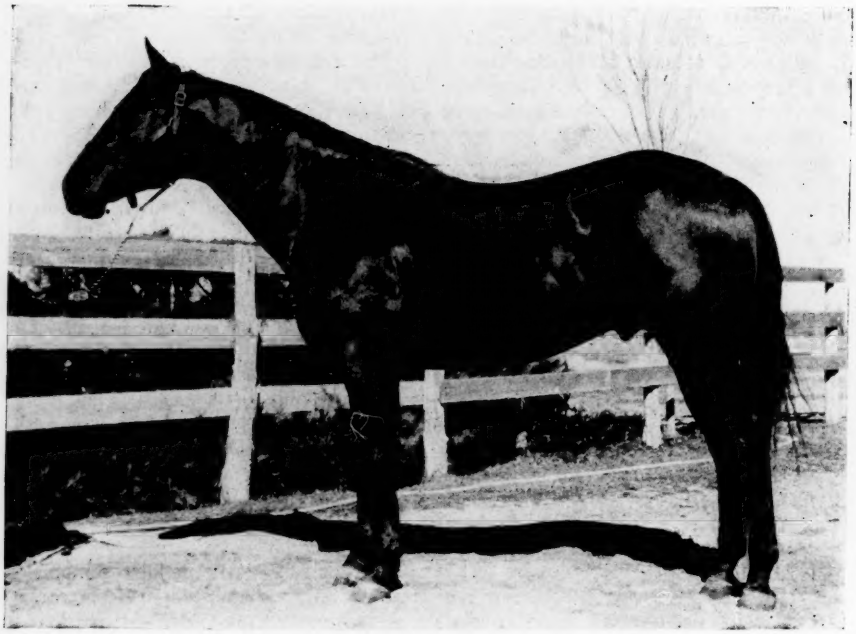
Analysis of Matings

When Old Sorrel had been proved as an outstanding sire, he was repeatedly mated to Thoroughbreds, to Quarter Horses and to crossbred mares of these two breeds. Of the 77 pedigrees of this study, 41 trace back to foundation mares of these three types, bred to Old Sorrel, to form a pool of genes made up of 65.8 per cent deriving from the Thoroughbred and 34.2 per cent from the Quarter Horse. Likewise 35 pedigrees trace back to foundation mares of similar breeding introduced into the line for use on sons or grandsons of Old Sorrel. This additional pool of genes was made up of 44.3 per cent Thoroughbred and 55.7 per cent Quarter Horse origin. One Arabian mare also appeared in several of the pedigrees.

The influence of the foundation Quarter Horses and Thoroughbreds, in terms of gene contributions, to 77 descendents depends on their position in the pedigrees and the system of mating employed. There was a small addition of Thoroughbred genes through the introduction of such straight bred Thoroughbred sires as Chicaro and Lovely Manners. More often Thoroughbred breeding was maintained at a rather high level through the frequent use of such sires as Solis, Cardinal and Little Richard, all sons of Old Sorrel out of Thoroughbred mares.

Constructive breeding, however, takes into consideration more than merely percentage of genes of a particular type or individual in a pedigree. It calls for the skillful planning of matings and expert attention to many other things. A genetic analysis of the pedigrees in terms of inbreeding and relationship is an important adjunct to such a project. It indicates the direction the breeding program has taken towards concentrating or disseminating the genes of such outstanding individuals of proven quality as Old Sorrel. In addition, the network pedigrees show graphically the systems of mating employed and are valuable as a guide to planning further matings.

The system of designating inbreeding and relationship used in this discussion is that developed by Wright.[4] In this system the coefficient of inbreeding measures the reduction in inbred individuals of the genetic heterogeniety present in the foundation stock. The coefficient of a relationship measures the extent to which the genes of two individuals are derived from common ancestors, as expressed by the degree to which characters of the related individuals should be correlated by reason of the common inheritance of non-dominant genes. These coefficients indicate the rapidity with which the genetic type of a desirable individual is being fixed in his linebred descendents. In terms of practical breeding this fixation may be highly desirable, if the chosen sire is



MACANUDO

Figure 7

This son of Old Sorrel has been mated mainly with his nieces, the outbred daughters of other sons of Old Sorrel, Cardinal, Little Richard and Solis. He is an outstanding example of the superior type of horse which has been most carefully selected to continue this breeding project.

free from recessive defects, or it may prove deleterious, even disastrous, if recessive defects crop out as a result of intensive inbreeding. The practical aspects of this balancing of factors which are one of the basic problems of the breeder are discussed in detail by Lush.[3]

Inbreeding to Four Sires

The interaction of these various factors in the formation of the King Ranch Quarter Horse strain is illustrated in the network pedigree of the foals by Wimpy (Figure 1). Wimpy is a double grandson of Old Sorrel, 12.5 per cent inbred to him, and was generally bred to daughters of Old Sorrel. Wimpy and the mares to which he was mated carry 50 per cent of the blood of Old Sorrel but due to the fact that all have different dams, they are only 25 per cent related to each other. In terms of proportion of common genes, this is equivalent to their being Wimpy's half-sisters. Wimpy's foals out of daughters of Old Sorrel are 62.5 per cent related to him which is 12.5 per cent more than the 50 per cent relationship of parent to offspring when inbreeding is not involved. This increase in relationship is equal to the per cent inbreeding of the offspring which itself is one-half the relationship of the parents to each other.

The mares to which Wimpy was bred made a pool of genes which averaged 60.3 per cent of Quarter Horse origin and 39.7 per cent of Thoroughbred origin. The scheme of mating used with Wimpy gave his progeny 67.7 per cent of genes from the Quarter Horse. This

is an increase from 60.3 in the dams. The genes contributed by Thoroughbreds decreased from 39.7 to 32.3 per cent. Most of the increase in Quarter Horse breeding among Wimpy's get was due to an increase of genes from Old Sorrel from 39.7 to 44.9 per cent. The genes from Old Sorrel were more concentrated in these foals than in their dams, but less than they were in their sire Wimpy, who got half his genes from his double grandfather.

Figure 4 shows a similar arrangement of the pedigrees of the foals by Peppy, a second King Ranch sire used in the program. He was a grandson, through Little Richard, and a great grandson, through Cardinal, of Old Sorrel and is 6.25 per cent inbred to him. In these matings, Peppy was for the most part mated to daughters and to double granddaughters of Old Sorrel. When mated to daughters of Old Sorrel, the relationship of the foals to Peppy was increased by 9.4 per cent above the 50 per cent relationship of non-inbred parents. Because of the inbreeding to Old Sorrel of double granddaughters, their foals by Peppy are likewise 59.4 per cent related to him. Several of the foals shown in the chart had a more involved inbreeding, and two of them were outbred.

The progeny of these matings with Peppy showed a slight reduction of genes from Old Sorrel, 40.3 per cent, as compared with 44.3 per cent for their dams. These foals had an increased percentage of genes of Thoroughbred origin, 37.1 per cent in the dams as compared with 46.8 per cent in their foals. Because most of the dams mated to Peppy were more closely related to Old Sorrel than was Peppy, the percentage of Old Sorrel genes in their offspring is higher than in Peppy.

Figure 6 shows that Macanudo, a son of Old Sorrel and out of a Quarter Horse mare, a granddaughter of Hickory Bill, was mated for the most part to nieces by half brothers and out of Quarter Horse outcross mares. Foals from this system of mating are 56.2 per cent related to Macanudo through Old Sorrel. This is increased to 58.5 per cent relationship when the inbreeding to Hickory Bill is also considered. Macanudo was also outbred to several Thoroughbred mares.

Macanudo, a son of Old Sorrel, more than doubled the percentage of genes from Old Sorrel in his foals (32.1 per cent) as compared with an average of 14.1 per cent in the dams to which he was mated.

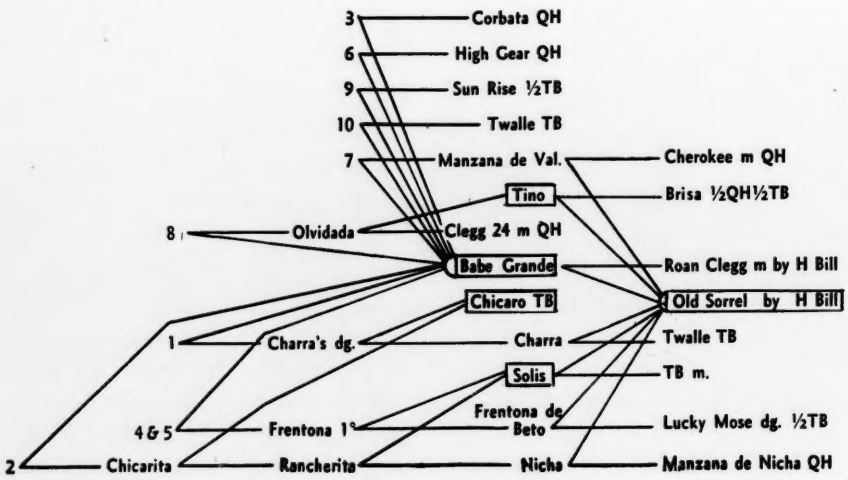
Many of the mares Macanudo was mated with were out of Quarter Horse mares mated to his half brothers, and because Macanudo's dam was also a Quarter Horse mare, in his foals the percentage of genes derived from Quarter Horses other than Old Sorrel (40.5 per cent), was materially increased over the percentage, 31.0, in the dams. As the genes from these sources were increased, those of Thoroughbred origin were nearly halved, dropping from 55.0 per cent in the dams to 27.4 per cent in the foals.

The remaining son of Old Sorrel used in this experiment is Babe Grande. His dam was a daughter of Hickory Bill mated to a Quarter Horse mare. Babe Grande was outbred to mares of Quarter Horse and Thoroughbred breeding and inbred to a number of daughters and double granddaughters of Old Sorrel. (Figure 8.)

About a third (36 per cent) of the genes of Babe Grande's colts were derived from Old Sorrel, whereas the average for the dams to which he was mated was only 22.5 per cent. A similar increase was obtained in Quarter Horse genes of other than Old Sorrel origin. The percentage of Thoroughbred genes was reduced from 43.5 per cent in the dams to 18.1 per cent in Babe Grande's foals.

Discussion

A study of the increases or decreases in gene composition of individual animals of each generation is more important than the group average compositions as given above. But these averages give a clear picture of the trend of the



MATINGS WITH BABE GRANDE

Figure 8

Babe Grande is a double grandson of Hickory Bill. Outbred to Thoroughbred and Quarter Horse mares, and inbred to daughters and granddaughters of Old Sorrel, Babe Grande raised the percentage of genes derived from Old Sorrel to over a third (36 per cent).

breeding program as a whole. Each year bands of brood mares are made up for pasture matings with various stallions. Such network pedigrees as the above, as well as an analysis of individual pedigrees, afford an objective basis for controlling the degree of inbreeding. They are of considerable assistance in planning matings so that the percentage gene composition of the future herd in respect to given individuals or types may be held within what the breeder conceives to be optimum limits. Such an approach gives a much clearer picture of the relationship and inbreeding involved in a breeding program than the old-fashioned "percentage of blood" concept.

These considerations will be increasingly important in succeeding generations as Old Sorrel and his sons and daughters recede into the background. By intensive inbreeding it is possible to retain a high degree of relationship to a noteworthy foundation sire for many generations as was demonstrated in the Dutchess strain of Shorthorns by Wright.[4]. The problem will become increasingly complex when the Registry Association closes its books so that further outbreeding to unregistered animals must stop. Such animals contributed very materially to the development of the modern Quarter Horse, and the elimination of this source of new genes will necessitate a more intensive use of superior individuals and strains within the breed.

While the results we have achieved have been most gratifying and have lived up to our expectations, few of the individuals thus far produced have had all of the desirable qualities that were present either in Old Sorrel or in his best sons and daughters. However, the experiment has now progressed to a point where we are nearing the production of large numbers of horses many of which approach the excellence of Old Sorrel himself. In a considerable number of instances, especially with respect to conformation and endurance, these recent products of the experiment are a real improvement on him. At this point, in matings where relationship has not been closer than between half-brothers

BABE GRANDE

Figure 9

Babe Grande is a son of Old Sorrel by a daughter of Hickory Bill. Less than a fifth (18.1 per cent) of the genes in Babe Grande's offspring are derived from Thoroughbreds in contrast to 43.5 per cent in the dams.

and half-sisters and where careful selection has been practiced, the results have been very gratifying. However, even better results have been obtained in cases where uncles and nieces have been mated, such as those mentioned in crosses between the Little Richard and Cardinal families.

All introductions of new blood were made not for the purpose of securing new blood, but to bring into the strain exceptionally fine qualities of individual mares. In all cases new Quarter Horse blood has been introduced through the female line. In this way any new blood brought in was quickly assimilated into Old Sorrel's family, and has not interfered with the development and perpetuation of the strain as a distinct family.

Since its inception nearly twenty years ago ten stallions and approximately 400 mares have been used in this experiment. All of the stallions, and approximately 10 per cent of the mares, are descendants of Old Sorrel. The line-breeding and inbreeding that has been employed has had up to the present moment the object of concentrating the blood of Old Sorrel rather than that of any of his descendants. At the present time, however, certain of his descendants are of such promise that line-breeding and inbreeding may well be directed primarily toward the concentration of

their blood rather than that of Old Sorrel. It is too early yet to predict which of the younger animals will be singled out as having such outstanding quality and prepotency. We can, however, say with great certainty that the family of Old Sorrel is now expanded into a strain that is extremely prepotent, made up of individuals which average very superior in physique and intelligence to any horses heretofore produced on the King Ranch.

From the point of view of the practical breeder it cannot be too often emphasized that biometrical tools such as coefficients of inbreeding and relationship, are not magic formulae which of themselves will assure the success of a breeding program. Linebreeding and other types of inbreeding are not of themselves capable of assuring automatically any particular result. The only effect of the concentration of genes of an outstanding individual through inbreeding is to fix a type. Whether the type that emerges is better or worse than the average will only be determined in th long run by the actual outcome of individual matings. The skill of the breeder and the care of the breeder in the choice of outstanding individuals as foundation stock, and in the planning of the individual matings, remains the all-important part of any breeding program. The breeder who attempts to work by formula or by rote is inviting disappointment and almost certain disaster.

In the Quarter Horse program at King Ranch the results of the rather intense inbreeding practiced have been overwhelmingly successful. Fortunately, there have been few instances of physical, physiological, or psychological defects or deficiencies which might be attributed to the inbreeding. We expect to continue for the present the same general scheme of mating that has up until now produced such gratifying results.

Summary

This study is an analysis of one of the outstanding families of the modern Quarter Horse in its formative stage. Through a judicious system of linebreeding as indicated in some of the pedigrees, the superb qualities of Old Sorrel can be carried on for many years to come.

NOTE: Additional information concerning percentages of inbreeding and blood relationships of all foals is contained in four detailed tables filed with the American Documentation Institute, 1719 N Street, N. W., Washington 6. D. C. To obtain copies, write directly to the ADI, listing author, title, document number 2312, and remitting money with order. Prices: Microfilm 50c, Photoprint 50c.

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Notice to All Members and Subscribers:

Segmental Interchange in the Mailing-Room

Through an unfortunate error, there has been a mix-up in the mailing of the May and June issues of the JOURNAL OF HEREDITY. The confusion has been considerable and its permutations numerous, with readers receiving such quantities as four of each, or none of either, or some of the chance variations lying between these extremes.

We regret the occurrence of this mistake and we are especially sorry if it has caused inconvenience to libraries, institutions or individuals, many of whom have been kind enough to bring the matter to our attention.

We wish to send out the missing journals as promptly as possible. Therefore we request that all those who have failed to receive either issue communicate with us immediately. Also, because the duplicate mailings have depleted our stocks, we request that the extra copies be returned to us. The address is: Amercian Genetic Association, 1507 M Street, Washington 5, D. C.

"MOTHER" AND "DAUGHTER" CHROMOSOMES

Significance of Heterocyclic Systems in Paired Nuclei

A. A. PROKOFIEVA-BELGOVSKAJA
Institute of Genetics, Academy of Sciences of the U. S. S. R.

OBSERVATIONS on the behavior of the cell nuclei in young potato tubers and in those aged until spring showed changes in nuclear conditions caused by differences in age, and differences between the paired daughter nuclei in the binucleated cells of the bark parenchyma.* As the aging of the tuber proceeds, the resting nuclei of the bark parenchyma undergo the following changes: by the end of starch-formation the nuclei have lost their spherical form; the nuclear contents (karyoplasm) have sharply decreased in volume; turgor of the nucleus has decreased, its membrane has become wrinkled and folds appear on the surface of the nucleus. The remaining contents stain intensively and diffusely. The nucleolus is poorly stained. The basophily of the chromonemata and chromomeres is strongly decreased (Figure 10). The nuclei in the cells of the bark parenchyma of unripe tubers are spherical in shape. The chromonemata and chromomeres form the basophilous fine structures of the nucleus. The karyoplasm is not stained at all.

Mitosis in the large cells of the bark parenchyma of young tubers gives rise to binucleated systems. The fragmoplast, developing in the cytoplasm, which forms a small region around the nucleus, is not able to divide the great body of the cell full of leucoplasts, starch grains, and vacuoles. As a result, the paired nuclei of the binucleated system are *"sister nuclei"* which have divided without being able to separate. The sister-nuclei in these binucleated cells are, as a rule, equal in size. In many cells they also appear similar to each other in their structure. But in a number of cases the nuclei of the binucleated systems differ markedly from each other. These differences can easily be seen both in "resting" nuclei and in those undergoing mitosis. The differences between the resting nuclei of the binucleated systems are as follows:

(1) The nuclei may be different from one another in regard to number of nucleoli.

(2) The nuclei may be markedly different in regard to degree of basophily of the karyoplasm (Figure 11).

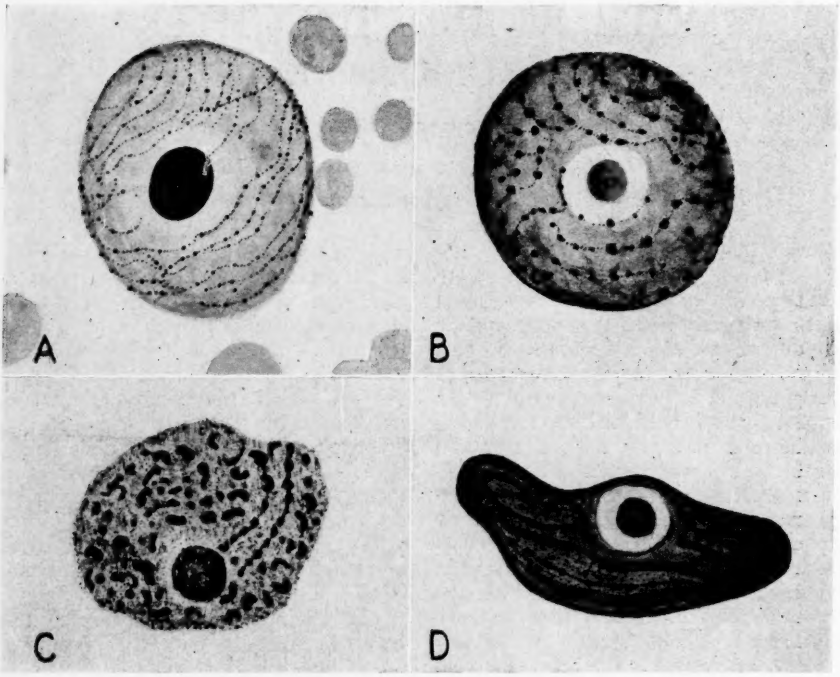
The Age Difference

Comparison of these data with those of Heitz on the behavior of the nucleolus in the nuclear cycle in *Vicia, Crepis, Aloe,* and *Allium*[13], leads to the conclusion that the cyclic conditions of the sister nuclei in the binucleated systems are different. One of the nuclei is older than the other. The heterocyclicity of the nuclei in the binucleated system is more markedly expressed in their mitotic cycle.

At progressive stages these differences are noted:

(1) At the prophase stage one of the nuclei contains fine fibres, intensively stained; in the other nucleus a knot of friable poorly basophilous fibres is observed.

*The material discussed in this report was obtained from tubers of the potato varieties Early Rose and Mayka taken at the time of harvest in 1942 and in the spring of 1943, before planting (Kirgiza). Small portions of the tubers, containing bark parenchyma, cambium, cork tissue and eyes were fixed with chrom-acetic formalin (10, 4 and 1 part respectively). Sections (8μ) were stained, according to Newton's method, with Dominici, haematoxilin Heidenhain, and gentian violet, and by the Feulgen method.



CHANGE IN THE CELL NUCLEUS WITH AGE

Figure 10

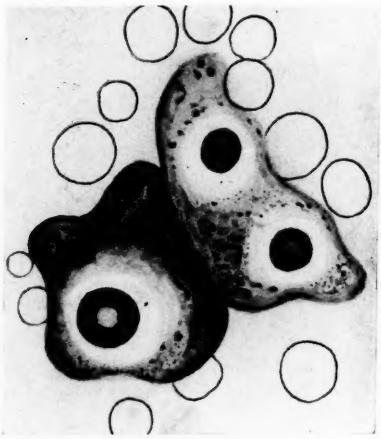
A—Structure on the metabolic nucleus in young potato tubers. The nucleus is spherical. The chromonemata and the chromomeres form a fine structure which stains strongly with basic stains (basophily). The karyoplasm (nuclear contents) does not stain. *B-D*—Structure of the nucleus in old tubers. The turgor of the nucleus decreases and the nucleus loses its spherical form. The karyoplasm stains diffusely and the basophily of the chromosomes and the nucleoli decreases. The chromonemata and the chromomeres form a coarse structure.

(2) In metaphase the chromosome conditions of both complexes are markedly different (Figure 12). One complex consists of poorly stained less compact chromosomes. Their cytological structure and outlines are not distinctly expressed (Figure 12, left). The chromosomes of the other complex (Figure 12, right) are thin and stained intensively. Their cytological structure is fairly well expressed. The whole region of the cell in which the set of less compact chromosomes is present is characterized by the diffuse staining, while the cytoplasmic region of the chromosome complex which is cytologically differentiated is completely clear.

(3) During anaphase the chromosome cycles of the sister nuclei are different. The chromosomes of the first complex have reached the poles while the chromosomes of the other set are only in anaphase (Figure 13). As mitosis of both nuclei occurs in a small space of cytoplasm the mitotic products of sister nuclei form two tetraploid or one octaploid nucleus.

Mitotic Phase

The binuclear systems of sister nuclei differ during mitosis in these three essentials:



BINUCLEAR SYSTEM SHOWING HETEROCYCLICITY

Figure 11

Metabolic nuclei in bark parenchyma of potato tubers. The nucleus with the single nucleolus, in which the karyoplasm shows definite basophilous staining, is marked as being the older of the two components of this system.

(1) At the resting stage in the number and size of their nucleoli and in the total basophily of the nuclear content,
(2) during prophase and metaphase in the structure and conditions of their chromosomes, and
(3) at the anaphase in the behavior of their chromosomes.

We conclude that in the mitosis resulting in the binuclear system, chromosome sets diverging towards opposite poles are not identical in their properties.

Mitosis as a Differentiating Mechanism

During metaphase the chromosomes of the one nucleus represent thick, less compact, poorly staining and poorly differentiating bodies, and in the other they appear as thin, pycnotic, intensely staining and well-differentiated structures. We conclude that the chromosomes which diverge at mitosis towards opposite poles differ in the physico-chemical properties of their protein component.

This difference in the structure of the sister nuclei is expresed in:

(1) a different bond with thymonucleic acid;
(2) a different density of their bodies;
(3) a different mode of spiralization, responsible for the manifestation of the morphological peculiarities of the chromosome.

In these binuclear systems one of the sister nuclei often differs from the other in these respects:

(1) It often contains one nucleolus, while the other contains two nucleoli.
(2) It often differs from its sister-partner by a stronger basophly of the karyoplasm, thus showing a resemblance to the nuclei of parenchyma cells at the period of starch formation.

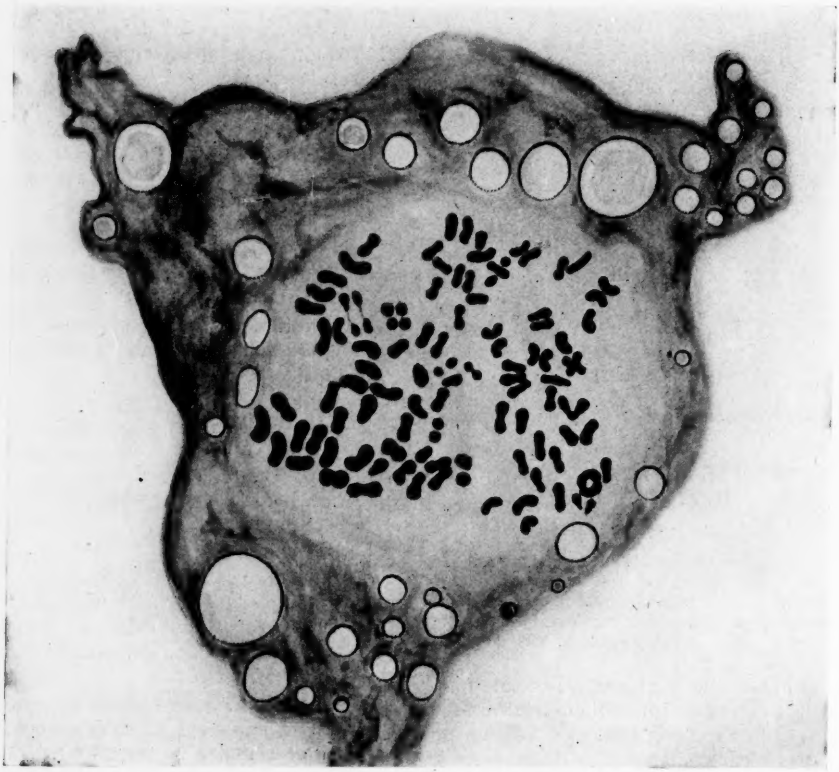
Therefore we conclude:

(1) the above described differences in the physico-chemical and structural properties of sister nuclei are accompanied by differences in their cycles;
(2) one of the chromosome sets arising at mitosis is an older chromosome complex as compared to its sister partner.

On account of the fact that in metaphase of binucleated cells *all* the chromosomes of one nucleus are typical intensive metaphasic and pycnotic bodies, markedly different from *all* the chromosomes of the sister nucleus which show less compactness and pure basophily, we conclude that in anaphase the chromosomes are distributed in relation to the poles of the spindle in such a way as to secure the travelling of all the "young" (pycnotic) chromosomes to one pole, and all the "old", less compact chromosomes to the other. Mitosis, in this situation, at least, is a division of the nucleus which is differentiating in relation to this chromosome condition.

A Suggested Conclusion

When analysing the facts given and conclusions drawn, we came to the fol-



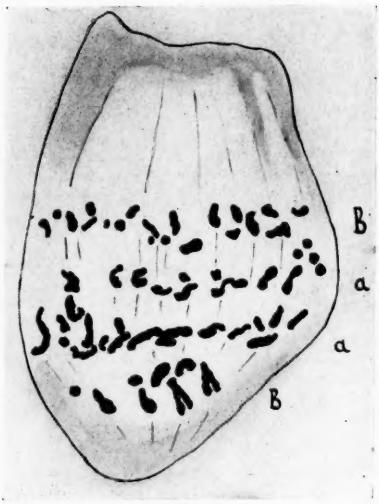
METAPHASE PLATE OF MITOTIC NUCLEUS SHOWING HETEROCYCLICITY

Figure 12

Nucleus of bark parenchyma cell of potato tuber showing existence of two distinct complexes of chromosomes differing in basophily. The complex of chromosomes on the right part of the nucleus are pycnotic and intensely stained. Those in the left sector are less deeply stained and not as compact. These are believed to be the older chromosomes, from which the "daughter" set on the right have arisen by "matrix-duplication" rather than by a splitting of entire "mother" chromosomes.

lowing suggestion: The sister chromosomes separating during mitosis to opposite poles are not identical with each other. Two chromatids arising at early prophase, which in structural relations are strikingly similar to one another, are different in their condition.

The explanation of this differentiation is to be found in the modern conception of the nature of chromosome reproduction[6, 9, 15, 18, 19, 21]. According to this conception, based on a consideration of the structure of proteins, every elementary chromosome region forms from the surrounding karyoplasm by means of autocatalysis a double or "copy" which completely corresponds to the initial chromosome structure. Therefore, the sister chromosomes are not "halves" of the maternal chromosomes, but "copies" of the original chromosomes, newly developed in each cycle. Taking this hypothesis, we regard the differences between the two chromosomes arising during mi-



MITOSIS OF TWO CHROMOSOME SETS IN A SINGLE NUCLEUS

Figure 13

Anaphase of two chromosome sets on a single spindle in a tetraploid nucleus. The chromosomes of one complex have already reached the poles (*B*). while the other complex is still in anaphase (*a*). Since this mitosis is taking place in a small volume of cytoplasm two tetraploid nuclei or one octoploid nucleus will be formed.

tosis as the difference between the original ("old") chromosome, that served as a basis of the autocatalytic processes and its "young" double or copy. Two chromosomes arising during mitosis are to be regarded as maternal and daughter chromosomes, rather than as two sister chromosomes.

The maternal and daughter chromosomes, i.e. the original chromosome and its "copy" developed adjacent to it, though corresponding closely to one another structurally, differ in the physico-chemical pecularities, as we think, of their protein components. These differences are responsible for the differences in their density, connection with thymonucleic acid, and spiralization. All these differences lead to the differences in the cycles of the original (maternal) chromosome and its "double" or daughter chromosome. Thus the maternal and daughter chromosomes form a heterocyclic system.

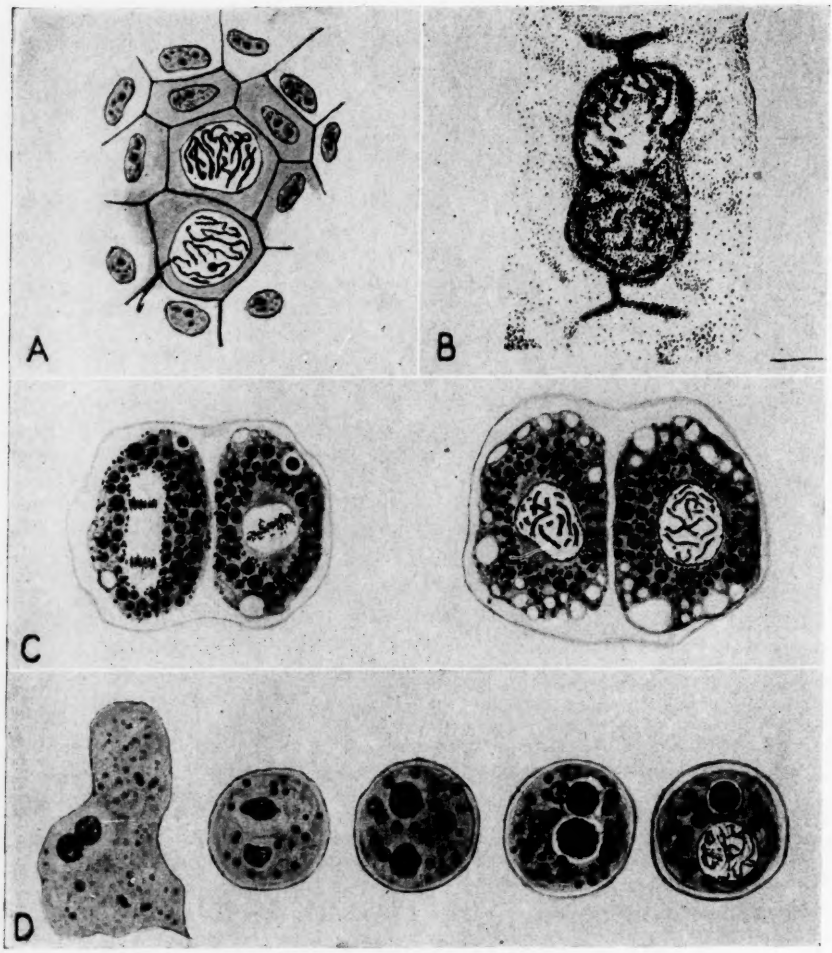
The Literature of Heterocyclicity

In cytological literature we have many cases which show heterocyclicity of sister nuclei. The difference in conditions of sister nuclei can be seen in Häcker's drawing (1895), representing "die beiden Abkömmlinge der Stammzelle" of *Cyclops brevicornis* (Figure 14*A*). The difference between the pycnotic generative and the diffuse vegetative nuclei of the pollen tube is conditioned, we suppose, by the difference existing in the system of "maternal-daughter" chromosomes. The difference in the condition of sister nuclei can be seen in Lindegren and Rumann's drawing (1938), representing the early telophase of mitosis in the ascus of *Neurospora crassa.* (Figure 14*B.*)

With surprising clearness a high degree of heterocyclicity of sister nuclei is expressed in cytological material of algae, fungi and protozoa.* The structure and behavior of the sister nuclei arising in a progametic mitosis of *Actinophris sol* is given in Figure 14*C*. A differentiation of the cycle in the sister nuclei is seen during all the stages preceding their fusion. In sister metaphases just as in those in *Solanum tuberosum,* there are formed in one nucleus the compact, weakly basophilous chromosomes while the pycnotic, intensively staining chromosome bodies are formed in the other nucleus[2]. A quite extraordinary significance attaches to the fact that in this mitosis in many algae, fungi and protista the outcome is sex differentiation of the cell.

Discussing this fact Hartmann writes: "Dann folgt aber daraus, dass hier durch eine einfache somatische Kern-

**Actinophris sol,* (Belar, 1922, 1926), *Amoeba diploidea* (Hartmann-Schilling, 1917), *Adelea ovata* (Jollos, 1929), *Cylindrocystis brebissonii* (Kaufmann, 1914), *Stylorrhynchus longicollis* (Léger, 1904), *Bursaria truncatella* (the third division of micronucleus) (Poljansky, 1934).

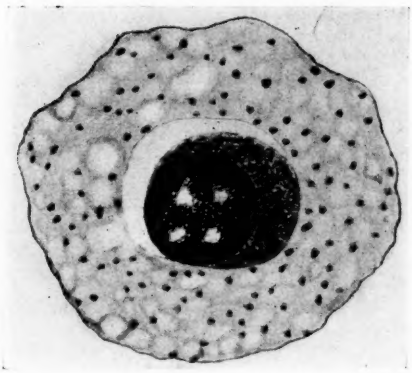


HETEROCYCLICITY OBSERVED BY OTHER AUTHORS

Figure 14

A—Heterocyclic system in *Cyclops brevicornis*, from Häcker, "die beiden Abkömmlinge Stammzelle," 1895. *B*—Mitosis in ascus of *Neurospora crassa*, early telophase showing differences in nuclei. From Lindegren and Rumann, 1938. *C*—Heterocyclicity in sister nuclei arising in progametic mitosis in *Actinophris sol*. The differential basophily of the two chromosome complexes is clearly visible. From Belar 1922 and 1926. *D*—Heterocyclicity of sister nuclei in *Amoeba mira* arising by amitosis. After Gläzer, 1912, from Belar, 1926.

theilung, bei der an dem Kern keine genotypische Änderung eintritt, die Töchterkerne eine männliche und weibliche Tendenz erhalten . . . . Diesen Fall erscheint theoretisch dishalb besonders wichtig, wiel er zeigt, dass die sexuelle Differenzierung, die Herbeinführing einer sexuellen Tendenz an eine Kerntheilung gebunden sein, ohne dass dabei genotypische Verschiedenheiten im Chromosomenbestand zustande kommen." (Hartmann[11] 1929.)



HETEROCYCLICITY IN PROMITOSIS

Figure 15

Sister nuclei arising in promitosis in *Aulacantha scolymantha*, showing clearly marked differences in staining. After Borgert, 1909, from Hartmann, 1911.

Conclusions

Analysing all facts given above, we come to the following conclusion: the differentiation of the nuclei of lower plants and protista in regard to their sex is brought about by the separation of the elements of the system "maternal-daughter chromosomes". The difference in the cyclical conditions of sister nuclei determines the difference of their sex tendency. Thus, the sources of the sex differentiation of the cell nuclei lie in a universal peculiarity of the nucleus—namely in the chromosome capacity for self-reproduction. The heterocyclicity arising in the process of self-reproduction of the components of the system "maternal-daughter" chromosomes was the initial step in the evolution of sex.

The "Sekundärkernes" arising in promitosis in protista constitute pycnotic bodies clearly contained in the "Primärkerne". Hartmann[10] (p. 38) wrote about the "Secundärkerne" of *Aulacantha scolymantha* (Borgert[4]) the following: "Sie erscheinen als kleine Caryosomekerne, die von einer hellen Kernsaftzone umgeben sind." This case is represented in Figure 15.

The fact that in promitosis the primary nucleus and the secondary nuclei differ in regard to their basophily like the sister nuclei in *Solanum tuberosum* and *Actinophris sol*, leads to the suggestion that in promitosis and amitosis there occurs a total separation of entire sets of maternal and daughter chromosomes. In *Amoeba mira* the nuclei in the dicaryon system arise amitotically[7]. They differ sharply from one another in regard to their conditions. (Figure 14*D*). We suppose that the difference in conditions between daughter and mother chromosomes is a general feature of mitotic chromosomes, caused by the nature of their reproduction. But it is possible to demonstrate this in clear cytological pictures only in cases where division occurs after a long period of a metabolic nucleus stage.

The analysis of the chromosome condition at the metaphases of binuclear cells permits of the assumption that a lengthy functioning ("aging") of the chromosome leads in its protein component to a reduced capacity to form a bond with thymonucleic acid. The chromosomes then undergo mitosis while undercharged with nucleic acid. The data of Belozersky[3], involving measurement of the amount of thymonucleic acid in young and old cultures of *Spirillum volutans*, confirm the observations on the "young" and "old" chromosomes of *Solanum tuberosum*. At the same time our data as to the influence of age upon heterochromatization (Prokofieva-Belgovskaja, 1945) point to a shift in the cycle of the chromosome towards mitosis. A comparison of these data makes us conclude that, as they grow older, the chromosomes pass into a heterochromatized (mitotic) condition, characterized by a reduced bonding with thymonucleic acid.

Analysing the mitotic behavior of ring chromosomes, Darlington came to the conclusion that "there is an absolute distinction between a parent and a daughter thread in the reproduction of the chromosomes[5]."

The results of our studies confirm the correctness of this conclusion.

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A Brief Comment on Mother-Daughter Chromosomes

IT cannot be denied that Prokofieva's observations are most interesting, yet many readers will no doubt share the impression, which the present writer held at first reading of her paper, that her interpretation is not the most probable one. She thinks that in her material one can distinguish between a mother and daughter chromosome by its staining and general appearance. It can hardly be disputed that there is the difference she claims, in many cases, but it would, at first thought at least, seem more likely to have been caused by the nuclear environment of the two contrasted groups of chromosomes, the one group having been more immersed in the products of the old chromosomes and nucleus than the other group. If it were a matter of mother and daughter chromosomes being so distinguished it would appear exceedingly strange that all the mother chromosomes should go to one pole and the daughters to the other. While this would not be impossible, it would involve a new principle, and that principle might in itself be as important as the observable difference between the chromosomes.

Although the above difficulty would at first incline the reader away from the interpretation offered by Prokofieva, a little further consideration shows that there do exist situations in which groups of chromosomes become oriented so as to be drawn to a specific pole according to their possession of given properties, not primarily dependent on their cellular location. Some of the oriented cell divisions shown by Metz to occur in *Sciara* represent a case in point, and still more pertinent in this connection are the peculiar divisions recently reported by M. J. D. White in *Miastor,* where just one given set of chromosomes out of eight or more homologous sets seems somehow to be selected out for transportation to a given pole. Of course it is not known that they are selected on the basis of age, yet once the principle of a basis for preferential transportation of genetically identical chromosomes is admitted at all, it no longer appears nearly so improbable as it did originally that some peculiarity connected with the age of the chromosome could (by affecting this basis) lead to a segregational method of division.

The above discussion indicates that it is too much to expect of a paper, for its acceptance in a reputable journal, that its interpretation always seems correct to the critic or editor, so long as the observations are good and the position is at all defensible. If we had such a strict criterion it would throw out too many papers, including a good many correct ones, since it may often be the critic himself who is mistaken.

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CONCERNING MOTHER INDIA'S STARVING CHILDREN

IN the April issue of THE JOURNAL OF HEREDITY you carry an article entitled "Mother India's Starving Children" by the Managing Editor, Mr. Robert Cook. The problems set forth are desperate enough, without the injection of a Katherine Mayo note. You are on the right track when you suggest that "science can [perhaps] solve this problem [of overpopulation in India]." But in matters of social relations, what you derisively call "non-science" has higher claims than the Occidental's god of science.

Science has given us the most deadly weapons of human destruction including the atom bomb. Science can reveal to us the secret of the how—how things behave; it is incompetent to tell us the why—why things behave the way they do. The greatest value of science is in its impersonality, in its methodology. The realm of values is a stranger to science. The meaning of the cosmic process, the entelechy of man—these aspects of man's being, more important than the mechanism of chromosomes and genes, cannot be illuminated by the impersonal methods of science. For that we need religion—and philosophy.

Even social science, so long as it apes natural science in impersonality, is bound to be sterile. Unless it is infused with the spirit of what the Asians and Europeans call "the humanities," social science will at best give negative results in the understanding of man's behavior.

For all its arrogant boast, science cannot create something out of nothing. Science must start with a given. However much that given is refined by scientific analysis, the scientist cannot fathom the mystery of the why of the given. It may well be that the answers of religion, far from being valid, may simply have an air of plausibility. Indeed, the answers of religion may well be, at least partly, nothing more than wish-fulfilments. But when religion is dominated by philosophy, by the philosophic investigation of Truth, as Hinduism, the religion of Mother India, is, then the answers of religion have a validity transcending the limits of time and space.

A legitimate query may be made. Are you willing to carry over your "scientific" attitude toward India's acute food crisis of today to the diseased body politic of the Occident? The two World Wars are merely an expression of the "insanity that lies deep in the customs and beliefs of the people" of the Occident, to adapt a happy phrase of yours. In view of this situation, did you counsel, either during the First World War or the Second, that the best way to serve the Occident, and the world, would be to permit and encourage the complete annihilation of Europeans, the perennial war-makers of the world?

Mahatma Gandhi's immortal statement: "Non-violence is the law of our species as violence is that of the brute," cannot be derived from so-called science. And yet it is far more important for the well-being of man than all the fleeting "truths" of science put together. Sensitivity to human suffering is indeed the hallmark of humanity.

Whether the problem be the scourge of war or the scourge of famine, man's rational approach must be twofold: (1) to relieve the sufferings in the present and (2) to set about to work today so as to eradicate the root causes of the evil in such a thorough-going fashion that in the not distant future the scourge may be a mere memory. It is not a question of either-or, it is a question of both-and. If one values one's humanity, one must work on the two fronts simultaneously. I hope I am not taking too much for granted in believing that the scientist, too, like other ordinary mortals, values the human within himself—the same human that partakes of the nature of the divine.

For the integrity of her own soul, America must send all the food she can *today* to the starving millions of Europe, India and China.

So much for the integrity of science

and of the human soul. Now a word about the actual details involved in the Food-for-India appeal. I cannot understand *why* intelligent people fall a victim to the bugaboo of India's persistent natural increase. Let us be long-sighted, not short-sighted. A comparison of the figures for India's natural increase today with those of Germany's and Britain's natural increase seventy-five or a hundred years ago is apt to reveal that European countries in the initial stages of industrialism increased their populations about as fast as India is doing today. In other words, India's abnormally high natural increase today is not a unique phenomenon in the world's history—what is peculiar about it is that it is a present occurrence thanks to the very recent onset of industrialism in the land. What happened in Europe, and was gradually happening in Japan, namely, a decreasing rate of natural increase of the population, is bound to happen in India, thanks to the impersonal logic of technology. Let industrialism stabilize high wages and high salaries, let the purchasing power of the people be increased, let the standard of living rise, and we shall witness a falling-off in the birth-rate. On this proposition all competent students of population are agreed. It is not my judgment that the people in India are so unique, so different, that they could successfully defy the empirical experience of the human race.

Finally, India is not today asking for charity. She is willing to pay cash on the barrel for every ounce of food that may be released by the Combined Food Board in Washington, D. C. This is a short-range proposition. The long-range program is being tackled by Mother India's sons and daughters who are dedicated to increasing the purchasing power of the masses through industrialization, scientific farming, and public education in planned parenthood.

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IT is obvious that we must harness the hard-headed and factual approach of the scientist and the highest humanitarian motives of the altruist if any of the peoples of the world are to escape the fruits of their different "insanities of belief and custom." And I hope that I made it clear that the beam in the Occidental eye is no less fraught with danger than the mote in the Oriental eye. We have been no more successful in meeting a population crisis in Puerto Rico than the people of India have been with theirs. Before the "philosophers" figure out the "Ultimate Why," we are going to have to figure out a few workable "Hows" by using our heads for something besides beautiful abstractions. Unless we manage this all the transcendentalism in the world won't save us from drowning millions in a sea of blood.

It is rather startling that a disciple of the non-violent Mahatma should seem implicitly to recommend the annihilation of the entire population of Europe. All tht I have stressed is the urgent need to *stabilize*—not *exterminate*—populations in areas where mouths exceed subsistence. It appears, however, that the "immortal" principle of non-violence is developing limitations. The *San Francisco Chronicle* for August 4 quotes a message from Ghandi to Hindu farmers whose crops are being damaged by monkeys. This behavior of our simian cousins is so alarming as to justify an open season: "If we must save society as well as ourselves from the mischief of monkeys and the like we must kill them." Clearly then, since the past century's goings-on in Europe have wrought more havoc than the most mischievous monkeys ever could, and since the greater bane demands, certainly, not a milder remedy, it is obvious that extermination comes under this dispensation, being necessary to save society and ourselves. Personally I would prefer a less bloody solution: to try what I advocated in India, namely a rational tinkering to modify the insane beliefs and customs which produced the impasse in the first place.

If it should transpire that Ghandi's open

season can be extended to include control of the hordes of useless cattle that must be far more destructive to crops than monkeys, we might be on the verge of a new era, an era in which reforms might be unimpeded by anachronistic and traditional beliefs. For neither cows nor monkeys contribute more than a fraction of the mischief that India's unbalanced birthrate does. If Ghandi could abandon the unrealistic attitude that "celibacy in marriage" is the only way to achieve "planned parenthood" a new day of real hope might dawn for the people of India.

Let's glance briefly at Professor Muzumdar's plan to solve India's greatest problem by repeating the mistakes made in Europe during the last two centuries. Industrialization in Europe worked precisely because it occurred there first, and therefore most of the rest of the world constituted virgin territory, open to exploitation as markets for manufactured goods. An increasing imbalance between mouths to feed and the land to feed them could only be equilibrated where mass imports of food were possible, these to be paid for by export of industrial products. The chickens of such an essentially unstable and parasitic economy have been coming home to roost in increasing numbers. This in part—and only in part, of course—accounts for Europe's tragic record, which Professor Muzumdar now suggests we should close by obliteration.

What Professor Muzumdar proposes for India is essentially to repeat this tragic fiasco on a hugely expanded scale, in a world already industrialized. And even if this were possible, and markets existed, the situation of India today is vastly different from that of Europe in 1750. Industrialization in Europe started *before* the big explosion of population, which is the first reaction to industrialization. India stands today in industrial development where Europe stood two centuries ago, but she already has nearly half a billion people living below subsistence. The explosion of population, *which occurs before the decline in the birthrate sets in,* is still in the future. The declining birthrate which Professor Muzumdar pins his hopes on cannot be expected until the present population has tripled or quadrupled. A country cannot merely wave a philosophic wand and become industrialized, as the Soviet Union has been finding out. And incidentally, in the Soviet Union, a country far more industrialized than India, and with a much higher standard of living, the birthrate is booming.

Industrialization in a stabilized population might help, but are there any prospects of that? The exhaustive Report of the Health Survey and Development Committee for India, published by the Government of India in March 1946, gave consideration to this possibility and saw no hope that it might come to pass. The Mahatma's mandate regarding celibacy in marriage was considered to be an effective bar to birth control education; custom forbade a campaign to increase age at marriage; and there were no likely possibilities that anything else could be done. The conclusion was that the population would increase twice as fast in the next decade as it has since 1930, upping the total, in spite of famines, some 83 million people by 1955.

In the face of this appalling prospect, a long-range program which contemplates meeting the crisis by "increased purchasing power through industrialization, scientific farming, and public education in planned parenthood" is about as realistic as borrowing Chamberlain's umbrella to protect us from the atom bomb. The crisis is real and urgent. Verbal transcendentalism cannot possibly be enough. In the present context *food shipments only mean more deaths by famine in the long run.* Hence food alone is not a solution of the problem—rather an aggravation. Is it possible that Ghandi's dictum regarding the monkeys means that the leaders of Indian thought are beginning to wake up to this?—R. C.

CORN COB "FUR"

Figure 16

The insert shows approximately natural size a side view of a fragment of a corn cob covered with "fur" where grains ought to be. The larger photograph shows the same fragment enlarged about three times, as viewed from above. looking down on the surface that should be covered with grains of corn. The "fur" is red in color, with a sprinkling of white hairs. Details of structure are shown in Figure 17.

CORN COB FUR*

FREDERICK D. RICHEY

GRAINS METAMORPHOSED INTO "FUR"

Figure 17

Enlarged (× 10) view of a section of the "furred" corn cob, showing details of structure. The fibrous bundles push out from the centers of aborted ovaries, of which fragments of the wall still remain. The fibers are hollow and rather more fragile than most vegetable fibers. Hence "corn-fur" will not soon become a competitor of cotton or flax. Nothing is known regarding the genetic or environmental factors which caused this strange variation.

SOME years ago, Mr. George C. Foster of the "Highbank" farm, near Chillicothe, Ohio, gave the writer what appeared at first glance to be a small rabbit's foot. The specimen had been found by Clarence Lee, Mr. Foster's tenant, in a load of corn cobs being brought from the local elevator. A second glance showed that the specimen was, in fact, a short split piece of a corn cob covered with a hair-like growth. Figure 16 shows an enlarged (3 ×) top view of the fragment, and gives an excellent idea of its monstrous appearance. The insert shows a side view of the entire fragment approximately natural size. The fur or hair is reddish (Ridgeway's rufous), but an onset of senility is indicated by a liberal sprinkling of white hairs.

The why and the how of the specimen can never be known. There is even uncertainty as to the exact what of the hairs. They appear to be wild fibers from the vascular system, and to originate from the part of that system which

*Joint contribution from the Bureau of Plant Industry. Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and the Tennessee Agricultural Experiment Station.

normally supplies the developing kernels. Figure 17 shows a small portion of the specimen enlarged to ten diameters. This portion can be located in the right half of the insert in Figure 16.

The shadowy structures in various stages of dilapidation seen in Figure 17, are aborted ovaries of which only the walls (pericarps) have developed. It is from within these that the hairs emerge. Similar fibers occur in the large strands of vascular tissue which enter the butt of the cob, as seen at the right side of Figure 16. Others occur at various places and angles within the pith remnants. These are more understandable after seeing the illustrations of the vascular system in the recent paper by Reeves.* Whether these growths can properly be called fibers, or whether they are some other tissue gone wild is not known. Their structure is that of a tube with somewhat thickened walls. They have few, if any, cross walls, and they terminate in definite points (where they are in the clear). On the other hand, they are extremely fragile, in contrast to the normal condition of plant fibers, and they certainly would offer no hope for corn as a fiber crop.

Because of the unfortunate lack of all information as to the origin of the specimen, other than that given here, its sole interest is its utter and complete departure from the normal. And yet, it departs little, if at all, more than several of the known heritable variants in maize. Thus, pod corn, teopod, ramosa, tassel seed, etc., are as abnormal in their respective ways as is this specimen. Whether the cause was genetic or environmental can only be guessed. To the writer a genetic cause seems less unlikely. However that may be, the fragment adds one more instance to the long list of cases that reveal the extreme teratology in corn.

*Reeves, R. G. Methods for studying the maize ear. *Bot. Gazette*, 107:425. 1946.

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The College Birthrate

THE 1940 U. S. Census confirmed and measured the extent of the differential birthrate which for several decades at least has been an increasingly marked feature of our culture (see the March JOURNAL OF HEREDITY for details). That, during the Colonial period the present inverse relation between ability and fecundity was much less marked, or even reversed, is stressed by Dr. Clarence J. Gamble in introducing his own most recent findings regarding the size of families of Harvard and Yale graduates (*Human Fertility* 11:41-47, June 1946). In the early Eighteenth Century Yale graduates averaged better than five children surviving to maturity, indeed a startling contrast to Gamble's findings regarding the reproductive achievements of Yale graduates in the second decade of the present century. These early intellectual Sons of Eli actually exceed by nearly an entire child the most fecund group turned up by the 1940 Census enumeraters, i.e., the women with no formal education (with about four children each) and the women with homes renting for less than $5.00 per month (with 4½ children each).

Dr. Gamble has brought up to date the earlier studies of fecundity of Harvard and Yale graduates. Taking his data from the books prepared for the 25th reunions of classes of 1916 to 1920, Gamble finds that there is a slight increase in the reproductive achievements of these graduates, as compared with earlier findings of Phillips, Osborn, and others. These studies found that during the first decade of this century the offspring of the graduates of Harvard, Yale and Princeton averaged about 1½ children, and Gamble finds that the Harvard 1916-1920 graduates averaged 1.73 children, and the Yale graduates averaged 1.70 children. In terms of current death rates an average of 2.2 children is necessary to maintain the numbers of a population. Hence this increase still leaves a sizable gap between actual reproduction and replacement.

About all that can be said for this showing is that it would be worse if the trends were in the opposite direction. Granting that graduating from college is only a rough and inadequate criterion of native intellectual ability, and that many in the underprivileged, undereducated group have abilities greater than their achievement status shows, nevertheless the statistical trends are clear enough. The reproductive differentials are so great that a fifth of a child one way or the other makes little difference. An increase of one or two children per graduate would redress this alarming balance. As Gamble correctly emphasizes, skimming the milk and throwing the cream down the sewer is bound to reduce the butterfat content of the milk. Indulging in Pollyanna talk because things are no worse is hardly realistic.—R. C.

POLYMORPHISM IN NATURAL POPULATIONS

Of a Species of Drosophila

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NATURAL populations of most species of Drosophila show very little variability in externally visible characteristics. Compared to many other insects, Drosophila species seem to be surprisingly uniform. One of the most striking exceptions to this rule recorded so far is *Drosophila cardini*, found in the West Indies, Florida and Panama. According to Sturtevant,[2] the coloration of the abdomen in *D. cardini* is quite variable, both among individuals collected in nature and among laboratory bred flies. He found these color variations to be purely phenotypic, as shown by the following quotation: "Dr. Metz and I have bred several stocks in the laboratory, and have found these variations not to be inherited, but to depend on the conditions under which the larvae develop."

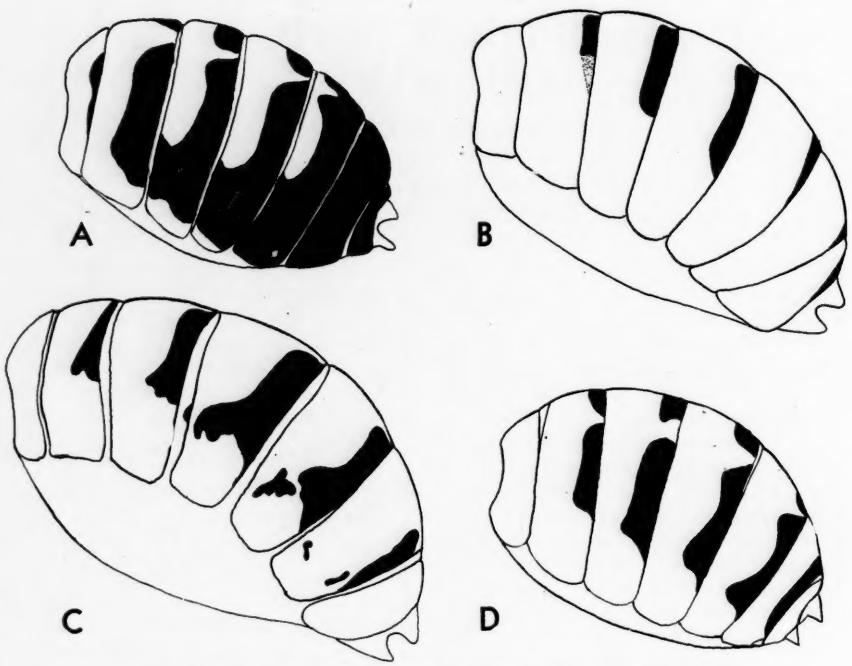
Dobzhansky and Pavan[1] described *Drosophila polymorpha* from southern Brazil, a species closely related to but not identical with *D. cardini* Sturtevant. The coloration of the abdomen in *D. polymorpha* also proved to be variable, both in the natural populations studied by Dobzhansky and Pavan and by the writer, and in laboratory cultures. However, in contrast to the findings of Sturtevant and Metz in *D. cardini*, the variations in *D. polymorpha* proved to be inheritable. The present paper is a preliminary report on the results of studies on the heredity of the abdominal color patterns in the latter species. The writer wishes to express his appreciation to Professor André Dreyfus, not only for his guidance but also for making available his laboratory, and also to Drs. Th. Dobzhansky and C. Pavan for their advice and help in the preparation of the manuscript.

Strains of *D. polymorpha* have been established from Bertioga (type locality), Vila Atlantica, Araras, Mogi das Cruzes, Aguas do Prata and Campos do Jordão, all in the State of São Paulo, and from Tijuca and Jacarepagua in the Federal District of Brazil.

Description of the Variability

Flies from all these localities display a variation in the extent of the black coloration on the abdomen (Figures 18 and 19). One can distinguish two extreme forms, a dark one (Figures 18*A* and 19*A*) and a light one (Figures 18*B* and 19*B*), and a series of intermediates (Figures 18*C* and *D* and 19*C* and *D*). The intermediate forms show a greater variability than the extreme ones. Figures 18*C*, *D* and 19*C*, *D* give an idea of the limits of variation in the females and in the males of the intermediate type. It is, however, important that the variability of the intermediates does not overlap the dark and the light forms, so that the three classes may be rather easily distinguished. Moreover, to insure safe classification, one must make certain that the flies are at least a week old, because the abdominal coloration in *D. polymorpha* develops rather slowly after the flies hatch from the pupae, becoming definitive only after about five days at room temperature.

Attempts were made to obtain pure strains of flies of the three types just described. For the extreme dark and the extreme light types these attempts were at once successful, since one generation of selection is enough to obtain true breeding strains. Some dark and light strains so obtained have been bred for as many as 24 generations and re-



VARIATION OF ABDOMINAL COLOR PATTERNS—FEMALE

Figure 18

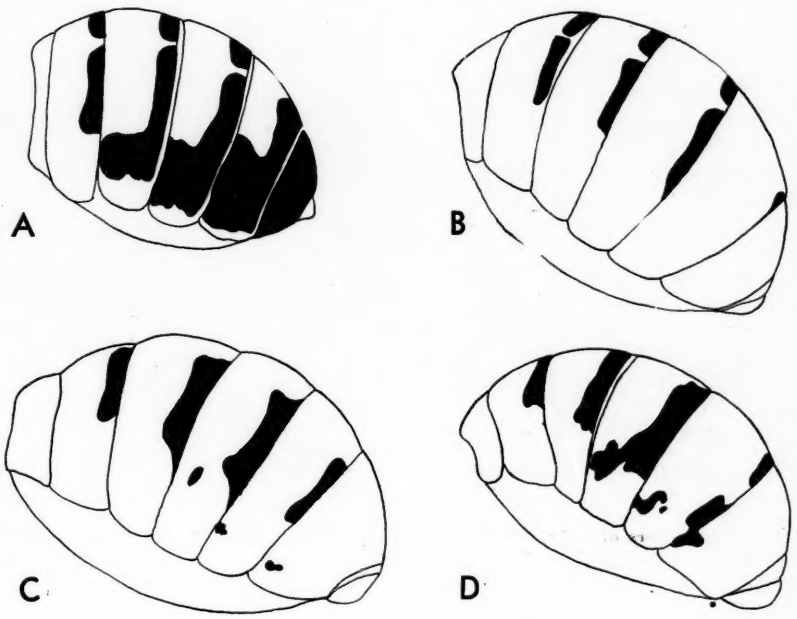
The colored areas on the abdomen of *Drosophila polymorpha* Dobzhansky and Pavan from Brazil display a wider range of variation than usual in an externally visible character in a wild species of this genus. Analysis of these pattern differences reveals that the most heavily pigmented form *A* and the least pigmented form *B* are homozygous. Crosses between them produce the heterozygotes *C* and *D*. These when interbred produce dark, light and intermediate forms, the dark and light forms being true breeding when interbred.

mained uniform. Such isolation of pure-breeding strains has been done starting with flies coming from various localities in the State of São Paulo and the results were always the same. This fact alone proves that the variation of the abdominal coloration in *D. polymorpha* is hereditary.

Crosses

Flies from the true-breeding light strains were crossed to those from the true-breeding dark ones. The F_1 generation always consists exclusively of flies of the intermediate class. The results of the reciprocal crosses, dark ♀ × light ♂, or light ♀ × dark ♂, are identical. Although the variation of the abdominal coloration in the F_1 flies is relatively greater than that in the pure dark and pure light strains, no overlapping is observed and no individuals resembling the parents occur.

The second generation, F_2, consists of individuals of all three classes, dark, intermediate, and light. The dark and light individuals obtained in F_2 are like those from the parental true-breeding dark and light strains respectively. The intermediates obtained in F_2 are as variable as those in the F_1 generation. It is interesting to note that many of these intermediates, in the F_2 as well as in F_1, have the dark pattern on the abdomen somewhat assymetrical on the two sides.



MALE ABDOMINAL PATTERNS

Figure 19

Like the females the male abdominal patterns of *Drosophila polymorpha* Dobzhansky and Pavan can be classified as dark (*A*), light (*B*) and intermediate (*C, D*) without overlapping. An analysis of the distribution of the four types in the second generation of the cross reveals that there is always a deficiency of the homozygous types (*A, B*). The enhanced chances of survival of the heterozygotes would account for the perpetuation of this polymorphism in nature.

Conclusions

The results obtained suggest that the observed variation in the abdominal pattern of *D. polymorpha* is due to two alleles of a single gene, neither of the alleles being either dominant or recessive. The relatively great variation observed in the heterozygotes may be explained in two ways. First, there may exist modifying genes whose effects are more perceptible in the heterozygotes than in the homozygotes. Second, it is possible that the phenotype of the heterozygote is more easily influenced by environmental changes than the phenotypes of the homozygotes. The data now available do not permit discrimination between these alternatives.

The Apparent Advantage of Heterozygotes

The numerical data observed in the F_2 segregations are tabulated on page 256. It may be noted that in both reciprocal crosses the numbers of the light and the dark flies obtained are below the expected numbers based on the 1:2:1 Mendelian ratio. On the contrary, the numbers of the heterozygous intermediate flies are greater than expected. The deviations are highly significant. The χ^2 for the light ♀ × dark ♂ cross equals 24.8, for the dark ♀ × light ♂ cross 57.4, and for the total 74.3. For two degrees of freedom, all these values have negligible probabilities of occurrence by chance.

The observed deviations from the

ideal Mendelian ratios indicate a relatively greater viability of the heterozygotes compared with the homozygotes. It must be noted that the mortality of the larvae and pupae in our experimental cultures is rather high. For reasons which are as yet unknown, a greater proportion of the heterozygotes than of the homozygotes reaches maturity in our cultures.

No data are available at present to show whether similar excesses of heterozygotes occur in natural populations as well. It may be noted that if the heterozygotes have a survival advantage also in the natural populations, this would explain the maintenance of the polymorphism in our species. If the heterozygotes exceed the homozygotes in adaptive value, natural selection will discourage the loss of either allele in the population. Our laboratory results were obtained using Bridges' banana agar medium, and at temperatures of 21-22° C. The selective process in nature seems to vary with the environment, since the proportions of the light, intermediate and dark types vary from locality to locality. An analysis of this problem is under way.

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TABLE I. Numbers of light, intermediate and dark individuals in the F_2 generation of different crosses.

CROSSES		LIGHT	INTER-MEDIATE	DARK	TOTAL
LIGHT ♀ DARK ♂	OBSERVED	478	1238	540	2256
	EXPECTED	564	1128	564	
	DEVIATION	-86	+110	-24	
DARK ♀ LIGHT ♂	OBSERVED	261	856	320	1437
	EXPECTED	359	718.5	359	
	DEVIATION	-98	+137.5	-39	
TOTAL	OBSERVED	739	2094	860	3693
	EXPECTED	923	1846.5	923	
	DEVIATION	-184	+247.5	-63	

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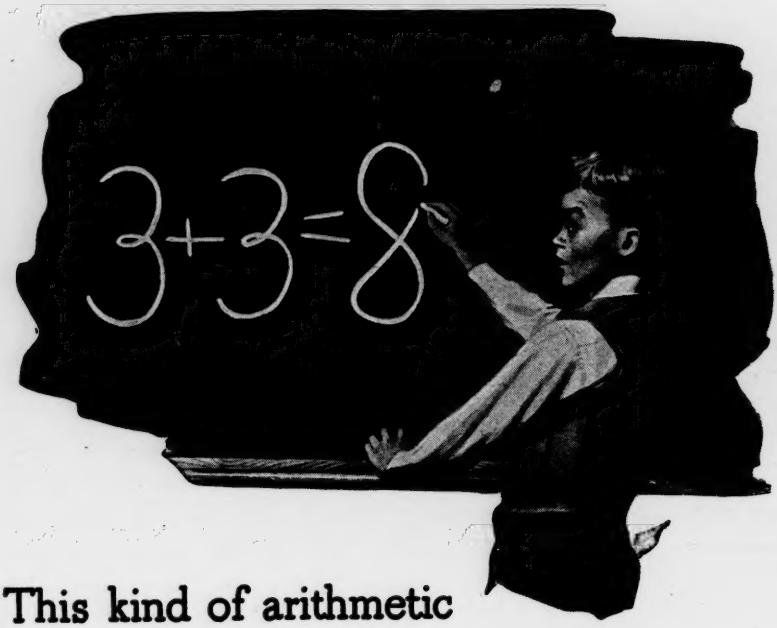

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